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Canadian Science Advisory Secretariat
Science Advisory Report 2007/021

ASSESSMENT OF SNOW CRAB IN THE SOUTHERN GULF OF ST. LAWRENCE (AREAS 12, E AND F)

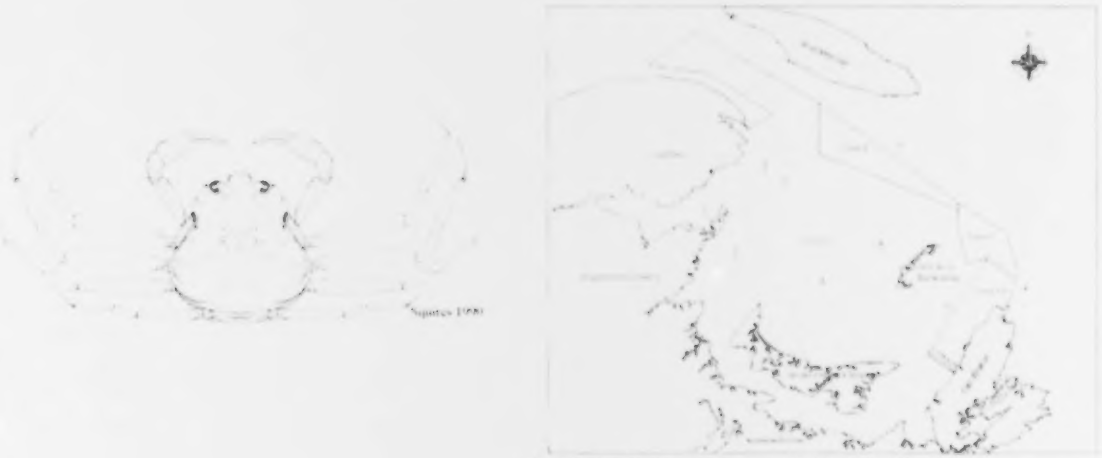

Figure 1: Map of the Gulf of St. Lawrence showing the Crab Fishing Areas (CFAs) and other areas.

Context

Snow crab, Chionoecetes opilio, has been commercially exploited in the southern Gulf of St. Lawrence (sGSL) since the mid 1960s. There are four individually managed fishing areas among which Area 12 (Figure 1) is the largest fishery in terms of its landings, fishable surface and number of participants. In Areas 12, E and F, the fishing season generally starts in April-May as soon as the Gulf is clear of ice and lasts approximately 10-12 weeks.

This fishery grew quickly from 1966, peaking at 31,500 t in 1982. Landings then remained around 25,000t until 1986 and then dropped to about 12,000 t in 1987-88. In 1989, the fishing season was closed early, with landings of 6,950 t, because of a rapid decline in catch-per-unit-of-effort (CPUE) and a growing incidence of soft-shelled males in catches. The quota was then set at 7,000 t in 1990. Since then, the landings have gradually risen and reached 19,944 t (quota of 20,000 t) in 1995 and gradually decreased to 11,136 t in 1998. Landings then rose to 32,336 t in 2005 but decreased by 20% at 25,869 t in 2006.

In support of the fishery, DFO Gulf Region Fisheries and Aquaculture Management request from DFO Science an assessment of the resource status and the consequences of various harvest levels for the coming fishing season. This document is a scientific overview of the assessment undertaken in support of the 2007 fishery. Commercial catch rates and other fishery statistics in the 2006 fishery are reported. An assessment of the status of Areas 12, E and F snow crab up to the end of the 2006 is made from fishery independent surveys using indicators of : abundance (fishable biomass index); reproductive potential (numerical abundance of mature females); recruitment; and exploitation rates (relative biomass exploitation rates and empirical exploitation rates).

June 2007

Canada

SUMMARY

- Crabs in management Areas 12, E, F and 19 are part of a larger biological population and the southern Gulf has to be considered as one unit for biological and assessment purposes.

Area 12

- The 2006 landings in Area 12 were 25,889 t (quota of 25,869 t).
- Partially standardized CPUE's remained high in 2006 at 64.4 kilograms per trap haul (kg/th) as in 2005 (63.7 kg/th).
- The incidence of soft-shelled crab remained low at 3.1%.
- The 2006 survey biomass index of commercial-sized crabs was 61,886 t (56,880 t – 67,210 t), which is comparable to the 2005 estimate of 62,939 t (58,840 t – 67,246 t).
- Seventy one percent (71%) of the 2006 survey biomass index is composed of new recruitment estimated at 44,087 t (39,970 t – 48,508 t).
- Empirical exploitation rates were calculated based on the ratio between the landings during the year and the sum of the landings and the residual biomass of the same year. Since 2000, exploitation rates calculated this way varied between 45 and 70% and are considered high compared to other snow crab fisheries.
- The recruitment to the fishery (R-1) is expected to decline in 2008 by approximately 50%. Recruitment will probably continue to be low until about 2011.
- The abundances of males smaller than 56 mm CW (R-5 and younger) have been low since the 2002 trawl surveys.
- The survey abundance of mature females has been decreasing since 1999 (the earliest year of the survey that can currently be used) while the mean size of mature females in the survey has been decreasing since 1988. The decrease in abundance is expected to continue. The estimated total egg production showed a decline since 2001 and reached the lowest observed in 2006.
- This fishery has become largely dependent on the annual recruitment to the fishery. If recruitment decreases as expected from 2008 to about 2011, the continued high exploitation rates combined with the expected low recruitment would result in a rapid decrease in commercial biomass.
- Limit and target reference points and comprehensive harvest control rules need to be developed and tested jointly by scientists, fishery managers and the fishing industry for the biological unit in the southern Gulf in the context of existing management areas.

Areas E and F

- Because of the unknown amount of crab movement in and out of these small areas within a given year, the estimates of commercial biomass index may not necessarily reflect the biomass at the beginning of the following fishing season.
- In both areas, the crab concentrations are found near the boundaries and the biomass estimates have large confidence intervals. Fishermen report concentrations along a continuous depth gradient in both areas.
- In Area E, the landings were 411 t representing 74.7% of their quota of 550 t. The partially standardized CPUE decreased from 80.6 kg/th in 2005 to 40.8 kg/th in 2006.
- The 2006 survey biomass index was estimated at 368 t (45 t - 1,394 t), a 56% decrease compared to the 2005 estimate of 845 t (417 t – 1,534 t).

- In Area F, landings were 787 t representing 96.7% of their quota of 815 t. Partially standardized CPUE in 2006 (55.9 kg/th) decreased compared to 2005 (93.7 kg/th).
- The 2006 survey biomass index of commercial-sized crabs was 562 t (74 t – 2,074 t), a 71% decrease compared to the 2005 estimate of 1,923 t (1,024 – 3,303 t).
- The Areas E and F are overflows (heavily influenced by) from Areas 12 and 19. The low survey biomass estimates and the rapidly decreasing CPUE, suggest that the biomass in 2007 in those areas is expected to be low. With the expected decline in commercial biomass and the overall retraction of the densities into the central part of the Area 12 after 2008, the commercial biomass is expected to decrease severely in the next few years.

BACKGROUND

Species Biology

Snow crab (*Chionoecetes opilio*) is a crustacean like lobster and shrimp, with a flat, almost circular, body and five pairs of spider-like legs. The hard outer shell is periodically shed in a process called moulting. After moulting, crabs have a soft shell for a period of 8 to 10 months. Soft-shelled crab is defined by shell hardness (<68 durometer units). The term "white crab" describes both new-soft (condition 1) and clean hard-shelled crab (condition 2).

Unlike lobsters, snow crabs do not continue to moult throughout their lives. Females stop growing when they acquire a wide abdomen for carrying eggs, which occurs at shell widths less than 95mm. Males stop growing when they acquire large claws on the first pair of legs, which can occur at shell widths between 40 and 150 mm. Females produce eggs that are carried beneath the abdomen for approximately 2 years. The eggs hatch in late spring or early summer and the newly-hatched crab larvae spend 12-15 weeks floating freely in the water column. At the end of this period, they settle on the bottom. It takes at least 8-9 years for males to reach legal size.

Fishery

Until 1997, the snow crab fishery in Area 12 (Fig. 1) has been exploited by 130 mid-shore fishermen from New Brunswick, Quebec and Nova Scotia. Since 1997, the PEI coastal fishery, (Areas 25/26) has been integrated into Area 12 to form one management unit. The number of active fishermen was 381 in 2006. In 2002, the status of Areas E and F was changed from exploratory to distinct permanent fishing areas and, in 2003, Area 18 was integrated into Area 12. For the purpose of this assessment, Area 12 refers to the new management unit. Areas 12, E and F, each has separate management scheme. There is no biological basis for these management areas.

The minimum legal shell width is 95 mm, and females are not kept by industry. Baited traps, constructed of wire or tubular steel, are used to catch crab, mainly on mud or sand-mud bottoms at temperatures ranging from -0.5 to 4.5°C and depths ranging from 50 to 280m. The fishery takes place in spring and early summer in Areas 12, E and F. Neither soft-shelled nor white crabs are harvested.

Management of these fisheries is based on quotas and effort controls (number of licenses, trap limits and seasons).

The 2006 fishing season in Area 12 opened on April 15 and closed on July 16 with reported **landings** of 25,889 t (quota of 25,869 t) (Table 1; Figure 2).

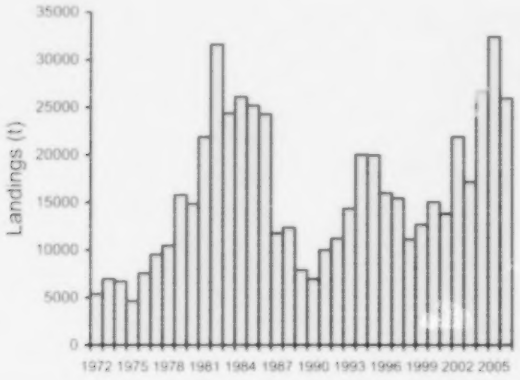

Figure 2: Landings (t) in Area 12 snow crab fishery.

In accordance to the soft-shelled crab protocol, a few grid areas were closed during the 2006 fishing season in Chaleur Bay, Shediac Valley and in the northern and southern parts of the Magdalen Channel. The fishing effort decreased from 508,053 trap hauls in 2005 to 402,702 in 2006 (Table 1).

Table 1. Quota, Landings, Fishing Effort and Catch Performance in Area 12.

	2002	2003	2004	2005	2006
Quota (t)	22,000	17,148	2.6,600	32,336	25,869
Landings (t)	21,869	16,898	26,626	32,363	25,889
CPUE (kg/trap haul)	40.2	50.0	54.9	63.7	64.4
Effort (# of trap hauls)	544,454	337,960	484,991	508,053	402,702
Mean size (mm)	109.0	110.4	110.4	111.8	112.0
Soft crab (%) in catches	4.6	3.3	3.0	3.9	3.1

The fishing season in Area E began on April 15 and ended June 24 with reported landings of 411 t representing 74.7% of the 550 t quota (Table 2). The fishing effort in Area E increased from 5,771 trap hauls in 2005 to 10,074 trap hauls in 2006.

In Area F, the fishery opened on April 15 and ended on July 15 with reported landings of 787 t, which represents 96.7% of the 815 t quota (Table 3). The fishing effort increased from 5,112 trap hauls in 2005 to 14,079 trap hauls in 2006. The quota in Area F increased from 480 t in 2005 to 815 t in 2006.

Table 2. Quota, Landings, Fishing Effort and Catch Performance in Area E.

	2002	2003	2004	2005	2006
Quota (t)	163	350	350	450	550
Landings (t)	165	345	349	449	411
CPUE (kg/trap haul)	56.6	63.1	55.6	80.6	40.8
Effort (# trap hauls)	2,916	5,471	6,277	5,571	10,074
Mean size (mm)	107.2	108.8	110.8	112.7	113.0
Soft crab (%) in catches	0.3	1.2	1.5	2.9	7.8

Table 3. Quota, Landings, Fishing Effort and Catch Performance in Area F.

	2002	2003	2004	2005	2006
Quota (t)	378	808	808	480	815
Landings (t)	378	817	806	479	787
CPUE (kg/trap haul)	85.2	78.1	74.8	93.7	55.9
Effort (# trap hauls)	4,437	10,460	10,775	5,112	14,079
Mean size (mm)	109.3	111.0	112.1	113.6	112.3
Soft crab (%) in catches	0.5	0.4	0.6	0.8	3.5

Catch per unit of effort (CPUE) are calculated from logbooks and must be viewed with caution and may be not representative of the commercial biomass because (1) CPUE is affected by many factors (socio-economic, soak time, trap type and size, type of bait, mesh size, weather, and the abundance of hard-shelled adult males), (2) the soft-shelled crab protocol may have an impact on the fishing performance.

In Area 12, the partially standardized mean CPUE (soak time is not taken into account) remained high in 2006 at 64.4 kg/th as in 2005 (63.7 kg/th) (Table 1; Figure 3). CPUE in Area E decreased in 2006 (40.8 kg/th) compared with 2005 (80.6 kg/th), as well as the CPUE in Area F where it decreased in 2006 (55.9 kg/th) compared with CPUE in 2005 (93.7 kg/th) (Tables 2 and 3).

The **percentage of soft-shelled crabs** and the **mean size of commercial-sized crabs** are calculated using data collected from the at-sea observer program.

It is important to note that the incidence of soft-shelled crab in catches is strongly influenced by the fishing strategy used by fishermen during the season, as well as crab abundance in the area.

In Area 12, the percentage of soft-shelled crab has been decreasing since 2001 and remained low at 3.1 % in 2006 (Table 1; Figure 3). The estimated discard mortality of soft-shelled crabs decreased from 391,559 crabs in 2005 to 243,353 crabs in 2006.

Figure 3: Catch rates (kg/trap haul) and percentage of soft-shelled crab in Area 12.

The percentage of soft-shelled crabs in Area E increased from 2.9% in 2005 to 7.8% in 2006, which was comparable to 1999-2000 (8%) (Table 2). In Area F, the percentage of soft-shelled crabs also increased from 0.8% in 2005 to 3.5% in 2006 (Table 3).

In Area 12, the **mean size of commercial-sized crabs** has increased since 2002 from 109.0 mm of carapace width (CW) to 112.0 mm CW in 2006. In Area E, the mean size of commercial-sized crabs increased from 105.8 mm CW in 2000 to 113.0 mm CW in 2006. In Area F, the mean size of commercial-sized crabs increased from 107.9 mm CW in 2000 to 113.6 mm CW in 2005, but decreased to 112.3 mm CW in 2006.

Carapace condition in Area 12 was estimated from sea samples taken during the 2006 fishery (Table 4). Crabs with carapace condition 3 comprised the bulk of the landings in all areas. The low percentages of carapace conditions 4 and 5 since 2001 suggest that exploitation rates are high. Similar trends occurred in Area E (Table 5) and Area F (Table 6).

Table 4. Composition (%) of the catch of commercial-sized adult crabs by carapace condition for Area 12.

Condition	1 & 2	3	4	5
Description	White	Intermediate	Old	Very Old
2000	11.5	64.4	19.3	4.8
2001	6.0	82.7	9.5	1.8
2002	4.7	86.4	8.2	0.7
2003	3.7	87.6	8.1	0.6
2004	3.4	86.7	9.2	0.7
2005	4.4	89.6	5.5	0.5
2006	4.2	88.9	6.4	0.5

Table 5. Composition (%) of the catch of commercial-sized adult crabs by carapace condition for Area E.

Condition	1 & 2	3	4	5
Description	White	Intermediate	Old	Very Old
2000	4.3	77.1	13.9	4.7
2001	0.9	84.8	12.8	1.5
2002	0.7	91.7	7.1	0.5
2003	2.6	92.0	5.3	0.1
2004	0.3	95.0	4.1	0.6
2005	1.9	95.1	2.4	0.6
2006	1.9	92.9	4.7	0.5

Table 6. Composition (%) of the catch of commercial-sized adult crabs by carapace condition for Area F.

Condition	1 & 2	3	4	5
Description	White	Intermediate	Old	Very Old
2000	6.5	84.4	8.1	1.0
2001	1.7	87.8	10.0	0.5
2002	14.7	79.8	5.4	0.1
2003	0.8	92.2	6.5	0.5
2004	1.7	87.1	10.7	0.5
2005	3.0	89.6	7.1	0.3
2006	3.8	91.6	3.6	0.9

ASSESSMENT

Stock Trends and Current Status

Fishable Biomass

Conclusions about stock status are primarily based on annual trawl surveys conducted during July to October, which provide an index of commercial biomass (hard-shelled adult males of legal size) remaining immediately after the fishery. They also provide estimates of soft-shelled adult males larger than 95 mm CW (R-1) that will be recruits to the fishery the following fishing season. Abundance indices are estimated for future male recruitment to the fishery (prerecruits defined as R-4, R-3 and R-2). The prerecuits R-4, R-3 and R-2 represent male crabs with a carapace width range of 56-68, 69-83, and larger than 83 mm CW, respectively. A portion of these crabs could be available to the fishery in 4, 3 and 2 years, respectively. An abundance index of total adolescent males larger than 56 mm CW (R-4, R-3 and R-2 combined) is also estimated and used as an index of the incidence of soft-shelled crabs that may enter commercial traps the following fishing season.

Indices of future and current spawning stock abundance are estimated using female abundance estimates (pubescent and mature). The term pubescent refers to females with a narrow abdomen and orange gonads that will molt to maturity and mate the following year and become primiparous females (first brood). The term 'multiparous' refers to females which are carrying a brood for the second time or more. The term 'mature female', includes primiparous and multiparous females (excluding senile females).

Area 12

The 2006 trawl survey commercial biomass index at the time of the survey was 61,886 t with 95% confidence limits (95% CL) of 56,880 t – 67,210 t, which is comparable to the 2005 trawl survey estimate of 62,939 t (95% CL: 58,840 t – 67,246 t) (Table 7; Figure 4). The recruitment to the fishery at the time of the survey estimated was 44,087 t (95% CL: 39,970 t – 48,508 t) comprising 71% of the commercial biomass index. This recruitment to the fishery is comparable to the 2005 estimates of 44,291 t (95% CL: 41,580 t – 47,130 t). The concentrations of the 2006 trawl survey commercial biomass were located in the American Bank, Shediac Valley, Bradelle Bank and in the Magdalen Channel (Figure 9).

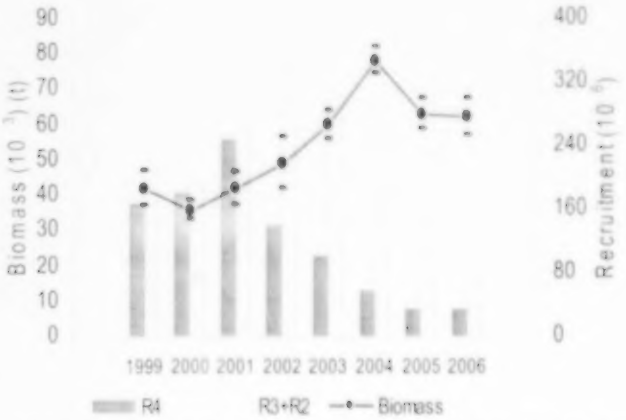

Figure 4: Survey biomass index (t) with a 95% confidence interval and abundance of future recruitment in Area 12.

Comparing survey estimates from one year to the next, and accounting for reported landings, the commercial-sized biomass index was 27.5% lower for 2005-2006 and 24.0% lower for 2002-2006. This loss of commercial-sized males could be attributable in large part to natural and fishing mortality, non-reported landings, and emigration.

A decline in the recruitment to the fishery is expected until 2011 because of the declining trend in abundance of prerecuit males (R-4, R-3, and R-2) observed in the trawl surveys since 2001 (Figure 4). In addition, low abundance of males smaller than 56 mm CW (R-5 and younger) were observed in the trawl survey since 2002 which may affect the recruitment to the fishery after 2011 (Figure12).

A high proportion of adult males < 95 mm CW compared to the total abundance of adult males was observed in the trawl surveys in the recent recruitment wave (Figure 5).

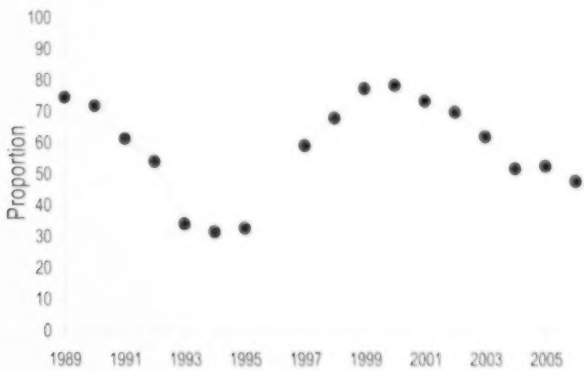

Figure 5: Proportion of adult males < 95 mm CW to adult males based on the trawl survey estimates.

This change in size structure of adult males suggests that high exploitation rates of larger-sized adult males may have caused the adolescent males to molt to adult phase below commercial size since they do not have to compete with larger-sized adult males in reproductive activities. This problem has occurred in other fisheries (e.g. Dungeness crab *Cancer magister* in the

Northeast Pacific). The contribution of the adult males < 95 mm CW to reproduction could cause a shift in size structure of the population in the long term.

Areas E and F

The commercial biomass indices in Areas E and F have wide confidence intervals. Moreover, there is an unknown amount of crab movement in and out of these areas within a given year. Therefore, the annual survey biomass index may not reflect the available commercial biomass at the beginning of the fishery. In both areas, the crab concentrations are near the boundaries and biomass estimates have large confidence intervals. Fishermen report concentrations along a continuous depth gradient in both areas. Stock estimates for these small areas are uncertain and may not predict the biomass at the time of the fishery.

In Area E, the commercial biomass index from the 2006 trawl survey was 368 t (95% CL: 45 t - 1,394 t), a decrease of 56% compared to the 2005 estimate of 845 t (95% CL: 417 t – 1,534 t) (Table 7). The recruitment to the fishery index, 236 t (95% CL: 19 t – 1,037 t) is 64% of the 2006 survey biomass index. The uncertainties in predicting biomass in this small area are confirmed by the inability to track cohorts. Moreover, the estimated abundance of prerecruits ≥ 56 mm CW in the southern Gulf has been decreasing and has become more restricted to the central part of Area 12 (Figure 10). This process may negatively affect the recruitment to the fishery and commercial biomass indices in Area E after 2007. The biomass indices in Area E should be interpreted with caution, because the crab concentrations are located at the boundaries of the area sampled and biomass estimate indices have large confidence intervals.

In Area F, the commercial biomass index from the 2006 trawl survey was 562 t (95% CL: 74 t – 2,074 t), a 71% decrease compared with the 2005 estimate of 1,923 t (95% CL: 1,024 t – 3,303 t) (Table 7). The recruitment to the fishery index of 397 t (95% CL: 38 t – 1,643 t), is 71% of the 2006 commercial biomass index. Low abundances of adolescent crabs observed from the survey may indicate that the recruitment to the fishery will decrease for the coming years. In addition, the prerecruits ≥ 56 mm CW in the southern Gulf have become more restricted in the center of Area 12 (Figure 10), which may also affect the emigration of crabs into Area F. The biomass indices in Area F should be interpreted with caution, because crabs are located at the boundaries of the area sampled and biomass indices have large confidence intervals.

Table 7. Survey biomass index (t) (adult commercial sized males with shell condition 3, 4 and 5) in the southern Gulf of St. Lawrence (with 95 % confidence intervals).

Survey Year	12	E	F
1999*	**41,923** 37,271-46,991	**1,237** 650-2,145	**1,811** 604-4,241
2000*	**35,442** 32,914-38,112	**551** 246-1,072	**2,782** 2,192-3,482
2001*	**41,665** 37,115-46,614	**750** 296-1,581	**3,803** 2,794-5,059
2002*	**48,788** 41,941-56,429	**919** 458-1,654	**3,922** 2,991-5,051
2003**	**59,558** 55,520-63,808	**856** 442-1,505	**3,070** 2,137-4,275
2004**	**78,025** 74,282-81,906	**867** 462-1,487	**2,133** 1,270-3,367
2005**	**62,939** 58,840-67,246	**845** 417-1,534	**1,923** 1,024-3,303
2006**	**61,886** 56,880-67,210	**368** 45-1,394	**562** 74-2,074

Biomass (projected) at the time of the survey of adult males with a CW ≥ 95 mm without considering the loss (mortality and migration).
* Fishing Vessel (FV) "Den C. Martin" (not adjusted to previous FV "Emy-Serge").
** FV "Marco Michel" (not adjusted to FV "Den C. Martin").

Reproduction

The abundance of the spawning stock and female-male ratio were studied to provide indications on **the current reproductive potential of the stock** in Area 12.

A decrease in the abundance of mature females has been observed since 1999 (Figures 7 and 11). The decrease in mature females is expected to continue given the low abundances of immature and pubescent females in the population in recent years (Figure 13). In addition, a decrease in the mean size of mature females since 1988 is mainly due to the decline in the mean size of multiparous females (Figure 6).

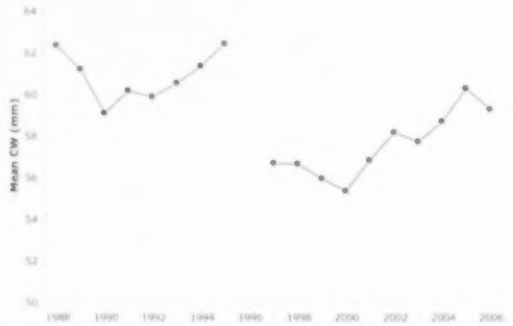

Figure 6: Annual mean size (mm) of mature females in Area 12 based on the trawl surveys.

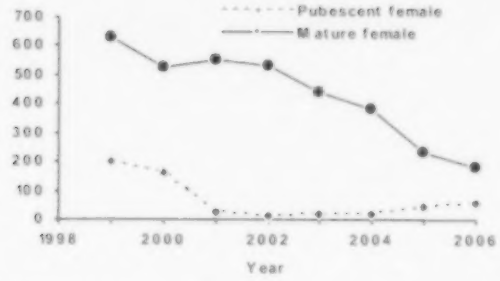

Figure 7: Annual female abundances (10^6) in Area 12 based on the trawl surveys.

The estimated total egg production showed a decline since 2001 and reached the lowest observed in 2006 (Figure 8). This information is consistent with the decrease in abundance of snow crab larvae measured from a mackerel egg survey conducted in the southern Gulf of St. Lawrence since 1983. The relationship between female abundances or total egg production, and future recruitment to the population is unknown. Computer simulations of currents and post-larval distribution have shown that larvae hatched in the southern Gulf of St. Lawrence (Bradelle Bank) may settle near Cape Breton, several hundred kilometers to the south under certain oceanographic conditions. Similarly, simulations have also indicated the possibility that larvae hatched in the northern part of the Gulf and the Saint Lawrence estuaries may settle via the Gaspé current in the southern Gulf where Area 12 fisheries take place. Nevertheless, the overall decrease in population fecundity in recent years may impact the recruitment of the population in the future.

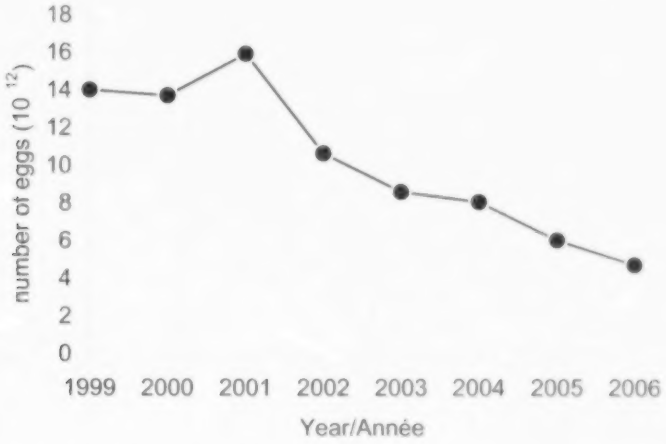

Figure 8: Estimated total eggs production of mature females in Area 12.

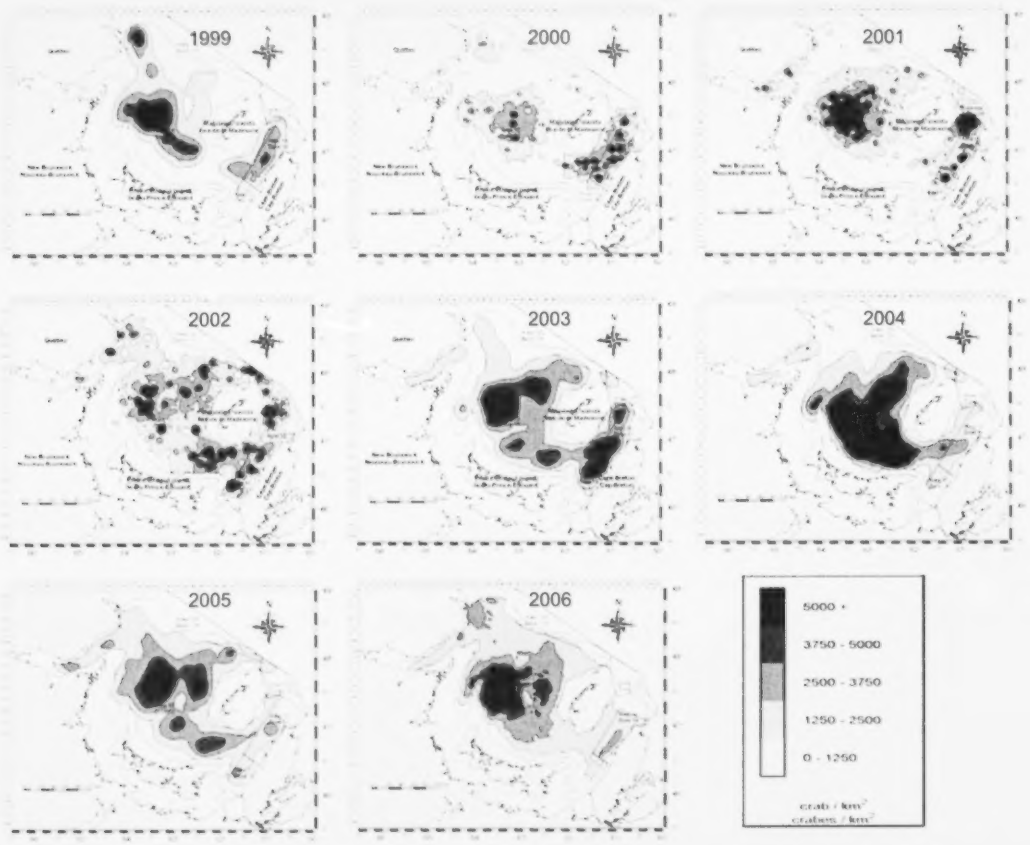

Figure 9: Density (number per km^2) contours of adult male crab ≥95 mm CW based on the trawl survey between 1999 and 2006 in the southern Gulf of St. Lawrence.

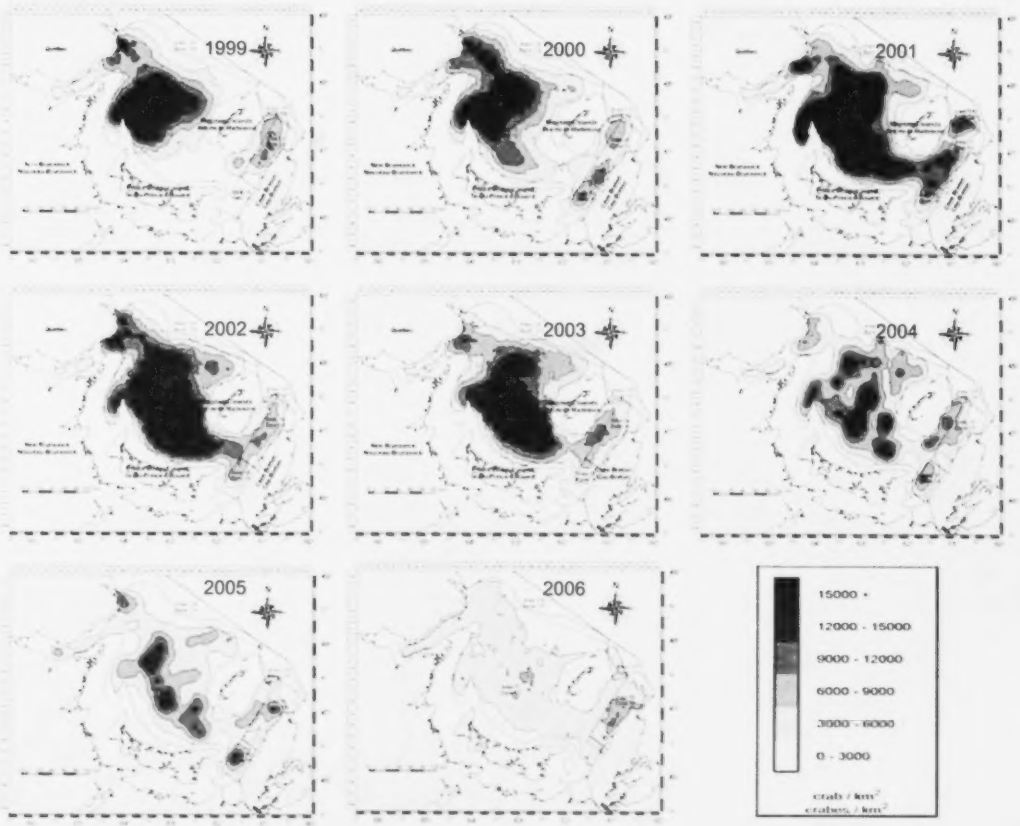

Figure 10: Density (number per km^2) contours of adolescent male crab ≥ 56mm CW based on the trawl survey between 1999 and 2006 in the southern Gulf of St. Lawrence.

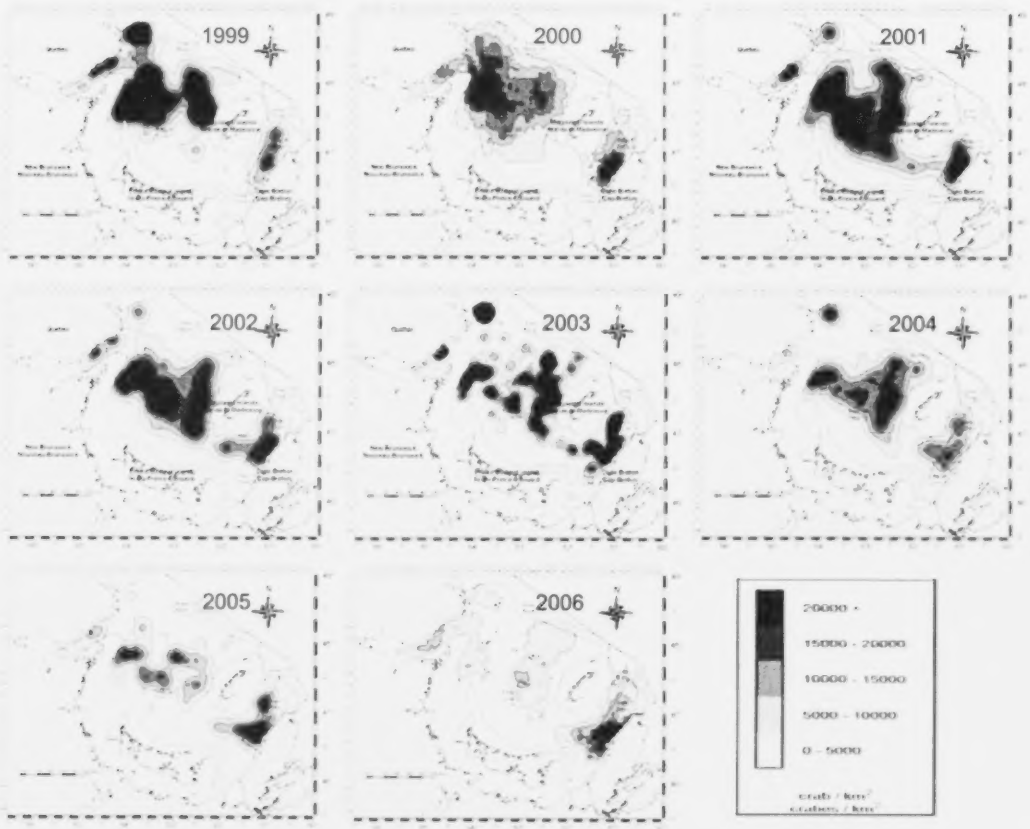

Figure 11: Density (number per km^2) contours of mature females based on the trawl survey between 1999 and 2006 in the southern Gulf of St. Lawrence.

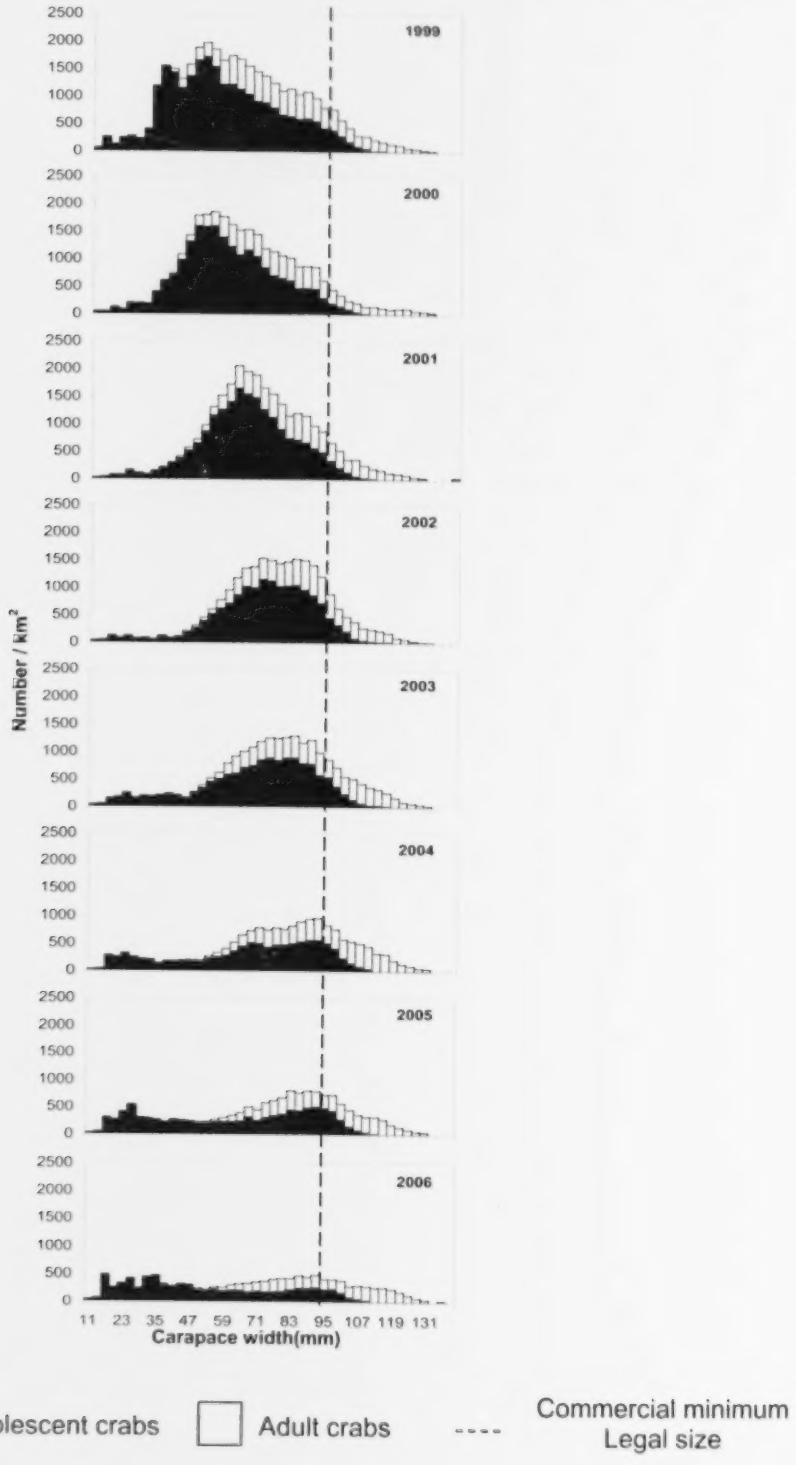

Figure 12: Size frequency distributions (number per km^2) of male crab sampled during the trawl survey in Area 12 after the fishing season.

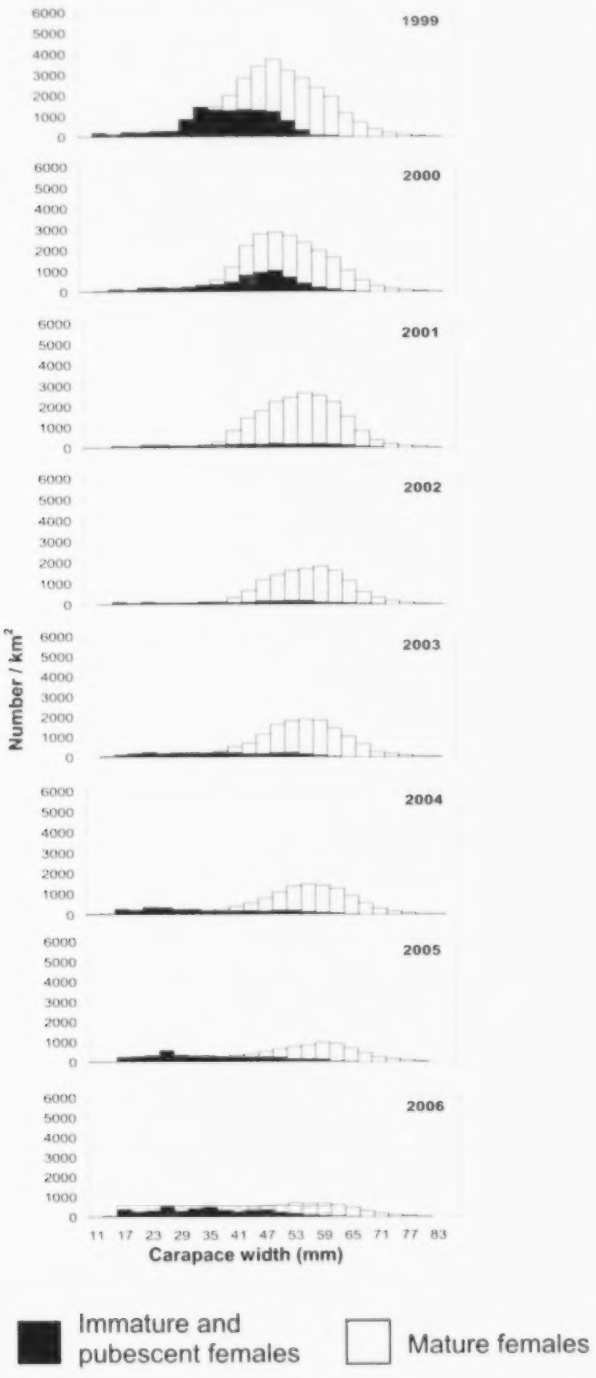

Figure 13: Size frequency distributions (number per km^2) of female crab sampled during the trawl survey in Area 12 after the fishing season.

Sources of Uncertainty

A change in the survey fishing vessels (FV) occurred from 1990 to 1998 (FV 'Emy-Serge D.'), from 1999 to 2002 (FV 'Den C. Martin') and since 2003 (FV 'Marco-Michel'). An increase in the number of sampling stations has occurred since 1998 and the trawl sampling protocols have changed. The commercial biomass index estimates prior to 1999 are currently under a thorough review.

The relationship between the dynamics of crabs in Areas E and F is a major source of uncertainty in managing fisheries in those areas. The relative abundance of prerecruits ≥ 56 mm CW in the southern Gulf have been decreasing and are restricted to the central part of Area 12. This may affect negatively the recruitment to the fishery in Areas E and F in the near future, adding further uncertainties and difficulties in estimating biomass indices.

The trawl survey is an important tool to provide annual abundance and commercial biomass indices, detect any anomalies in reproductive potential of the stock and estimate the difference in the estimates of commercial-sized crabs between the survey and the following fishing season. Without this sampling tool, the uncertainty in the overall assessment will increase substantially.

CONCLUSIONS AND ADVICE

For Area 12, the mean annual CPUE, low incidence of soft-shelled males and the mean size of commercial-sized adult crabs in commercial catches indicate that the fishery performance was good in 2006.

The Area 12 snow crab population is now in a phase of declining recruitment and the biomass of very old crabs is very low. The abundance of prerecruits has been declining since 2001 for R-4 and since 2002 for R-3 and R-2 suggesting that the abundance of commercial-sized adult males is to decline annually until probably 2011. Low abundances of crabs smaller than 56 mm CW (R-5 and earlier prerecruits) were observed since the 2002 trawl surveys, and suggests that recruitment may not increase quickly after 2011 when the next pulse of recruitment would be expected (Figure 12).

The fishery indicators in Area E were generally negative in 2006. The CPUE decreased compared to 2005. The mean size of commercial-sized adult crabs in commercial catches increased while the percentage of soft-shelled crabs increased during the 2006 fishing season. The commercial biomass estimated from the trawl survey decreased by 56% in 2006 compared to 2005. This fishery and stock dynamics are not independent of the stock condition in Area 12.

The fishery indicators for Area F were generally negative in 2006. The mean annual CPUE decreased while the percentage of soft-shelled crab increased in 2006. The mean size of commercial-sized adult crabs in the commercial catches decreased compared to 2005. The commercial biomass index decreased by 71% in 2006 compared to 2005 estimates. Moreover, the declining abundance of prerecruits to support this zone may contribute to an accelerated decline of commercial biomass in the near future. This fishery and stock dynamics are not independent of Areas 12 and 19 biomass conditions.

The recruitment to the fishery is now in a declining phase until at least 2011, when the next pulse in recruitment is expected. The rate of decline of the commercial biomass after 2007 will depend on the exploitation rate: higher exploitation rates will result in more rapid declines.

Higher exploitation rates also imply little accumulation of larger-sized adult males of carapace conditions 3 and 4, the most fertile males to mate with mature females. Since 2000, the percentage of adult males ≥ 95 mm CW with a carapace condition 3 in catches from the sea samples increased from 64% in 2000 to around 90% in 2005-2006 while the percentage of these crabs with carapace conditions 4 and 5 decreased from 24% to 6% during the same period (Figure 14). Although there was an increase in recruitment to the fishery from 2000 to 2005, the 40-50% relative biomass exploitation rate (calculated from the survey in the year before the fishery) used in Area 12 since 2000 did result in a low percentage of adult crabs with carapace conditions 4 and 5 in the catches and in the survey. Therefore since 2000, this fishery has become largely dependent on the annual recruitment rather than on the remaining biomass from one year to the next.

Empirical exploitation rates calculated from the ratio of landings during the year and the sum of the landings and the residual biomass of the same year varied between 45 and 70% since 2000. These values are considered high compared to other snow crab fisheries.

The recruitment to the fishery (R-1) is expected to decline in 2008 by approximately 50% based on the observed decrease of prerecruits R-2. Recruitment will probably continue to be low until about 2011. As indicated above, the continued high exploitation rates would result in a rapid decrease in commercial biomass.

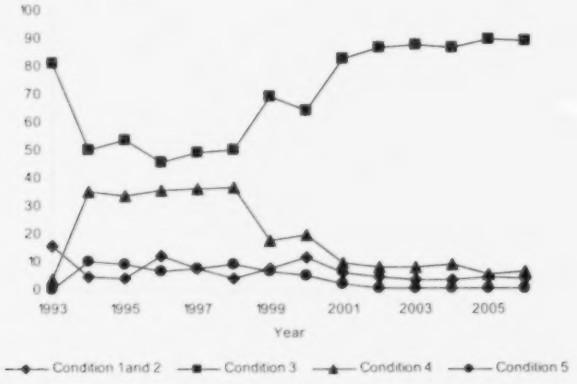

Figure 14: Annual percentages of different carapace conditions of adult male crab in Area 12 from the sea sampling.

Possible measure to maximize the reproductive output of the stock would be to open the fishery after the mating season of mature females (end of May) to increase the availability of large-sized adult males to participate in mating before being caught.

There would be biological benefits to the reproductive potential of the stock, and the future yields, if the fishery was allowed to return hard-shelled commercial-sized adolescent males to the sea, when caught in traps.

Substantial biological benefits are expected by the current soft-shelled crab protocol. Revision of the soft-shelled protocol may be an option to enhance the protection of the future recruitment to the fishery, especially during a decreasing trend in recruitment.

Areas E and F are highly influenced by Areas 12 and 19. The low survey biomass estimates and the rapidly decreasing CPUE, suggest that the biomass in 2007 in those areas is expected to be low. With the expected decline in commercial biomass and the overall retraction of the

densities into the central part of the Area 12 after 2008, the commercial biomass is expected to decrease severely in the next few years. Considering the uncertainties about the future recruitment to the fishery, a high exploitation rate would accelerate the decline in commercial biomass in the near future.

Limit and target reference points and comprehensive harvest control rules need to be developed and tested jointly by scientists, fishery managers and the fishing industry for the biological unit in the southern Gulf in the context of existing management areas.

OTHER CONSIDERATIONS

Ecosystem Considerations

Environmental factors, such as water temperature, can affect the molting and reproductive dynamic as well as the movement of snow crab. Chassé et al. (2007) reported that the bottom temperatures over most of the southern Gulf of St. Lawrence are typically less than 3 °C, which is considered suitable thermal habitats for snow crab. Water temperature data collected during fish surveys revealed that the bottom temperatures in deeper waters of Area E and F are higher (1 to 5 °C) than crab grounds (-1 to 2 °C) in Area 12. Chassé et al. (2007) reported that the bottom temperatures in Area 19 are usually 1°-2 °C warmer than the traditional crab grounds in Area 12.

In 2006, near bottom temperatures in area 12 were significantly above the average although the eastern portion had slightly lower temperatures compare to 2005. The snow crab habitat area index (total surface covered by bottom temperature between -1 and 3°C) was slightly below the long-term average and the mean bottom temperature within the habitat area was increased compared to 2005 (Figure 15). This temperature has shown an increasing trend since 1995. Snow crab occupies different depths in the water column at different life cycle stages. The temperature preference varies depending on the phase of the life cycle of snow crab, e.g. higher temperature may cause females change their reproductive cycle from two to one year in duration, lethal temperature for megalopae is known to be at around 18°C, immature crabs have a preference for colder temperatures while larger mature males have a tolerance to higher temperatures. However, the influence of habitat area and mean temperature on snow crab abundance and distribution is unknown.

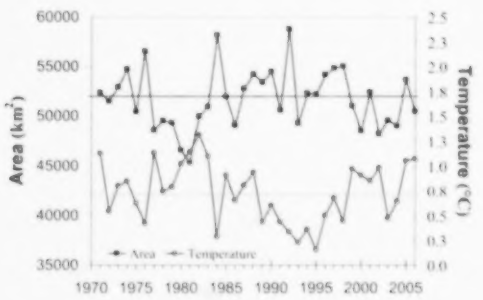

Figure 15: Snow crab habitat area and core temperature indices in the Southern Gulf of St. Lawrence.

Biological Considerations

Crabs in management Areas 12, E, F and 19 are part of a larger biological population and the southern Gulf has to be considered as one unit for biological and assessment purposes.

Close monitoring of the key events on population reproductive output (e.g., egg production, recruitment to the early benthic stages) is necessary to detect any anomalies on the quality and quantity of the spawning stock and subsequent recruitment.

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ISSN 1480-4913 (Printed)
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CORRECT CITATION FOR THIS PUBLICATION

DFO, 2007. Assessment of Snow Crab in the Southern Gulf of St. Lawrence (Areas 12, E and F). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/021.